COSEWIC
Assessment and Status Report

on the

Eastern Tiger Salamander
Ambystoma tigrinum

Prairie population
Carolinian population

in Canada

Prairie population – ENDANGERED
November 2013

Carolinian population – EXTIRPATED
November 2012

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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COSEWIC
Assessment Summary

Assessment Summary – November 2013

Common name
Eastern Tiger Salamander - Prairie population

Scientific name
Ambystoma tigrinum

Status
Endangered

Reason for designation
This salamander is known from only six sites in Canada within a landscape modified by livestock production, pastures, and forage crops, and intersected by roads. There are recent records from only one of these sites, and the species may be extirpated from one site. The persistence of populations is precarious because of the salamander's small Canadian range, isolation of populations, and the tendency of salamander numbers to fluctuate widely among years, exacerbated by increasing frequency of droughts and other severe weather events.

Occurrence
Manitoba

Status history
The Tiger Salamander (*Ambystoma tigrinum*) was originally assessed by COSEWIC in November 2001 as three separate populations: Great Lakes population (Extirpated), Prairie / Boreal population (Not at Risk), and Southern Mountain population (Endangered). In November 2012, Tiger Salamander was split into two separate species, Eastern Tiger Salamander (*Ambystoma tigrinum*) and Western Tiger Salamander (*Ambystoma mavortium*), each with two different populations that received separate designations. The Prairie population of the Eastern Tiger Salamander was designated Endangered in November 2013.

Assessment Summary – November 2012

Common name
Eastern Tiger Salamander - Carolinian population

Scientific name
Ambystoma tigrinum

Status
Extirpated

Reason for designation
This salamander was last seen in southern Ontario in 1915 at Point Pelee. Despite numerous surveys, it has not been seen since that time, and very little suitable habitat remains in this and surrounding areas.

Occurrence
Ontario

Status history
The Tiger Salamander (*Ambystoma tigrinum*) was originally assessed by COSEWIC in November 2001 as three separate populations: Great Lakes population (Extirpated), Prairie / Boreal population (Not at Risk), and Southern Mountain population (Endangered). In November 2012, Tiger Salamander was split into two separate species, Eastern Tiger Salamander (*Ambystoma tigrinum*) and Western Tiger Salamander (*Ambystoma mavortium*), each with two different populations that received separate designations. The Carolinian population of the Eastern Tiger Salamander was assessed as Extirpated.

COSEWIC
Executive Summary

Eastern Tiger Salamander
Ambystoma tigrinum

Prairie population
Carolinian population

Wildlife Species Description and Significance

Eastern Tiger Salamanders are robust mole salamanders and among the largest terrestrial salamanders in North America. Adults are primarily dark olive to grey or brown with lighter olive to yellow spots on the back and sides. The head is round when viewed from above, the eyes are relatively small, and the underside is dark with yellow blotches. The Eastern Tiger Salamander was recently recognized to be a separate species from other tiger salamanders based on genetic and morphological evidence. Thus much of the scientific literature on tiger salamanders does not distinguish the Eastern Tiger Salamander from what is now known as the Western (= Barred) Tiger Salamander, including its northern prairie subspecies, the Gray Tiger Salamander.

Distribution

In North America, Eastern Tiger Salamanders occur throughout most of the eastern United States. In Canada, Eastern Tiger Salamanders are known only from scattered locales in southeast Manitoba and from a historical (1915) record in extreme southern Ontario where the salamanders inhabit the Prairie and Carolinian Ecozones, respectively. These two populations represent separate postglacial range expansions into Canada and are considered separate designatable units in this report.

Habitat

Eastern Tiger Salamanders inhabit areas where sandy or friable (crumbly) soils surround fishless, semi-permanent or permanent water bodies that they use as breeding sites. These aquatic breeding sites are generally soft-bottomed, may or may not have abundant emergent vegetation, and must hold water at least for the 3 – 7 months needed for development until metamorphosis. Aquatic, neotenic adults (i.e., animals that retain larval form after sexual maturity) require fishless permanent wetlands. Terrestrial adult Eastern Tiger Salamanders burrow into deep friable soils using their forelimbs and tend to be associated with grasslands, savannas, and woodland edges adjacent to breeding sites and less so with closed canopy forests.

Biology

Eastern Tiger Salamanders living in northern locales breed in wetlands following warm spring rains within a few weeks of ice-off. To reach these breeding sites, adults migrate from terrestrial overwintering sites. Females lay clusters of darkly pigmented eggs below the surface of the water. Males reach sexual maturity in 2 years and females in 3 to 5 years. The generation time is approximately 5 years. Eastern Tiger Salamanders are visually oriented "sit and wait" predators and feed on a wide variety of aquatic and terrestrial invertebrates, tadpoles, and other salamanders. In turn, they serve as prey for predators such as fishes and invertebrates, garter snakes, and crows.

Population Sizes and Trends

There are no recent records of the Eastern Tiger Salamander from Ontario. There are recent records of the species from only one site in Manitoba, where its population sizes and trends are unknown. Studies conducted elsewhere indicate that Eastern Tiger Salamander populations are subject to fluctuations in abundance and are in decline in the mid-western and southeastern United States.

Threats and Limiting Factors

Like most amphibians with separate habitat requirements for adults and larvae, Eastern Tiger Salamanders must contend with threats and limitations in both aquatic and terrestrial habitats in increasingly modified environments. When migrating to and from breeding ponds, tiger salamanders are susceptible to road mortality. Loss or degradation of both the terrestrial and aquatic habitats required by Eastern Tiger Salamanders, as well as migration routes between these habitats, have detrimental effects upon the long-term persistence of populations. Introduced fishes present in Eastern Tiger Salamander breeding ponds will reduce or eliminate populations by preying on aquatic larvae. Increased incidences of drought have reduced populations in the southeast of their range in the US. Although adapted to life in semi-arid environments, tiger salamanders are vulnerable to prolonged, multi-year droughts that curtail breeding and can disrupt the structure of their populations within the landscape. Emerging infectious disease agents, such as ranaviruses and chytrid fungi, are potential threats.

Protection, Status, and Ranks

The Eastern Tiger Salamander, Carolinian population, in Ontario is listed under the *Species at Risk Act* (SARA) as Extirpated (it is listed as Tiger Salamander, *Ambystoma tigrinum,* Great Lakes population, as per the 2001 COSEWIC assessment). Eastern Tiger Salamanders in Manitoba are not listed under SARA.

TECHNICAL SUMMARY: Eastern Tiger Salamander - Prairie Population

Ambystoma tigrinum
Eastern Tiger Salamander
Prairie population
Range of occurrence in Canada: Manitoba

Salamandre tigrée de l'Est
Population des Prairies

Demographic Information

Generation time: Calculated based on estimated survival rates of adults	ca. 5 years
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals? Continuing decline is likely based on lack of recent records from all but one site and threats that are predicted to continue over the next 10 years (threat impact was rated as "high").	Unknown but likely
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased?	Unknown
Are there extreme fluctuations in number of mature individuals? Inferred from life history and information on large multi-annual fluctuations in abundance in other parts of the species' range. Females may forgo breeding for several years if conditions are unsuitable, resulting in multi-year pulses in breeding activity, followed by similar pulses in recruitment of young into the adult population. This pattern can result in extreme fluctuations in adult population size over longer time-spans.	Yes

Extent and Occupancy Information

Estimated extent of occurrence	770 km^2
Index of area of occupancy (IAO) (Always report 2x2 grid value). Discrete IAO derived from placing 2x2 km grid cells on extant known occurrences; one historical occurrence (1969, Steinbach) is excluded.	20 km^2
Is the total population severely fragmented? Small, isolated populations exist within fragmented habitat modified for livestock raising/agricultural uses and intersected by numerous roads. The viability of populations is unknown, but recent records exist from only 1 site.	Possibly
Number of locations: Each of the 5 extant sites in Manitoba is considered a single location, as each is vulnerable to a single threatening event, such as an extensive drought, introduction of predaceous fishes, chemical spill or epidemic disease that may rapidly affect all individuals present. It is unknown whether the salamanders continue to persist at each of these sites.1 historical site (1969, Steinbach) is excluded because there are no recent records, and habitat loss has occurred and continues to occur in this area that is experiencing human population growth.	5 or fewer
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	Unknown
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy?	Unknown
Is there an [observed, inferred, or projected] continuing decline in number of populations?	Unknown
Is there an [observed, inferred, or projected] continuing decline in number of locations*?	Unknown
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat? Inferred and projected decline.	Yes
Are there extreme fluctuations in number of populations?	Probably not
Are there extreme fluctuations in number of locations?	Probably not
Are there extreme fluctuations in extent of occurrence?	Probably not
Are there extreme fluctuations in index of area of occupancy?	Probably not

Number of Mature Individuals (in each population)

Population	**N Mature Individuals**
6 known sites, 1 of which is probably extirpated	Unknown
Total	Unknown

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Unknown

Threats (actual or imminent, to populations or habitats)

Agricultural activities (ranching, livestock and forage production), road mortality, pollutants, introduced predators (fish), emerging infectious diseases, prolonged droughts associated with climate change.

Rescue Effect (immigration from outside Canada)

Status of outside population(s):

As Eastern Tiger Salamander: SNR (not ranked) in Wisconsin and Minnesota. As Tiger Salamander (including both *A. tigrinum* and *A. mavortium*): S4 (apparently secure) in Wisconsin, and SNR (not ranked) in Minnesota.	
Is immigration known or possible?	Unknown but may be possible
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Possibly
Is rescue from outside populations likely?	Possible but restricted to areas near the border

Data-Sensitive Species

Is this a data-sensitive species?	Yes

Status History

COSEWIC: The Tiger Salamander (*Ambystoma tigrinum*) was originally assessed by COSEWIC in November 2001 as three separate populations: Great Lakes population (Extirpated), Prairie / Boreal population (Not at Risk), and Southern Mountain population (Endangered). In November 2012, Tiger Salamander was split into two separate species, Eastern Tiger Salamander (*Ambystoma tigrinum*) and Western Tiger Salamander (*Ambystoma mavortium*), each with two different populations that received separate designations. The Prairie population of the Eastern Tiger Salamander was designated Endangered in November 2013.

Status and Reasons for Designation

Status: Endangered (November 2013)	**Alpha-numeric code:** B1ab(iii)c(iv)+2ab(iii)c(iv)
Reasons for designation: This salamander is known from only six sites in Canada within a landscape modified by livestock production, pastures, and forage crops, and intersected by roads. There are recent records from only one of these sites, and the species may be extirpated from one site. The persistence of populations is precarious because of the salamander's small Canadian range, isolation of populations, and the tendency of salamander numbers to fluctuate widely among years, exacerbated by increasing frequency of droughts and other severe weather events.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable because population trends are unknown.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Endangered B1ab(iii)c(iv)+2ab(iii)c(iv) because EO and IAO are below thresholds for endangered (EO <5,000 km^2; IAO <500 km^2); Subcriterion a applies because there are 5 locations; b(iii) applies because habitat quality is declining; c(iv) applies because there are extreme fluctuations in the number of mature individuals.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable because population size and trend are unknown.
Criterion D (Very Small or Restricted Total Population): Not applicable because population size is unknown.
Criterion E (Quantitative Analysis): Not conducted due to lack of data.

TECHNICAL SUMMARY: Eastern Tiger Salamander - Carolinian Population

Ambystoma tigrinum

Eastern Tiger Salamander
Carolinian population

Salamandre tigrée de l'Est
Population carolinienne

Range of occurrence in Canada:Ontario

Demographic Information

Generation time: Calculated based on estimated survival rates of adults	ca. 5 years
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Not applicable
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Not applicable
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Not applicable
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Not applicable
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Not applicable
Are the causes of the decline clearly reversible and understood and ceased?	Not applicable
Are there extreme fluctuations in number of mature individuals?	Not applicable

Extent and Occupancy Information

Estimated extent of occurrence	0 km^2
Index of area of occupancy (IAO) (Always report 2x2 grid value).	0 km^2
Is the total population severely fragmented?	Not applicable
Number of locations	0 (formerly 1 known site)
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	Not applicable
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy?	Not applicable
Is there an [observed, inferred, or projected] continuing decline in number of populations?	Not applicable
Is there an [observed, inferred, or projected] continuing decline in number of locations*?	Not applicable
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat? Decline is observed, inferred, and projected.	Yes
Are there extreme fluctuations in number of populations?	Not applicable
Are there extreme fluctuations in number of locations?	Not applicable

Are there extreme fluctuations in extent of occurrence?	Not applicable
Are there extreme fluctuations in index of area of occupancy?	Not applicable

Number of Mature Individuals (in each population)

Population	**N Mature Individuals**
Ontario (Carolinian faunal province)	0
Total	0

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Not applicable

Threats (actual or imminent, to populations or habitats)

Not applicable

Rescue Effect (immigration from outside Canada)

Status of outside populations: As Tiger Salamander (including both *A. tigrinum* and *A. mavortium*): SX (presumed extirpated) in Pennsylvania, S1S2 (critically imperiled to imperiled) in New York, S3 (vulnerable) in Ohio and S3S4 (vulnerable to apparently secure) in Michigan.	
Is immigration known or possible?	No
Would immigrants be adapted to survive in Canada?	Possibly
Is there sufficient habitat for immigrants in Canada?	No
Is rescue from outside populations likely?	No

Status History

COSEWIC: The Tiger Salamander (*Ambystoma tigrinum*) was originally assessed by COSEWIC in November 2001 as three separate populations: Great Lakes population (Extirpated), Prairie / Boreal population (Not at Risk), and Southern Mountain population (Endangered). In November 2012, Tiger Salamander was split into two separate species, Eastern Tiger Salamander (*Ambystoma tigrinum*) and Western Tiger Salamander (*Ambystoma mavortium*), each with two different populations that received separate designations. The Carolinian population of the Eastern Tiger Salamander was assessed as Extirpated in November 2012.

Additional Sources of Information: A draft recovery strategy has been prepared (Ngo *et al.* 2009) and recommends no action be taken to re-establish the species.

Status and Reasons for Designation

Status: Extirpated (November 2012)	Alpha-numeric code: Not applicable
Reasons for designation: This salamander was last seen in southern Ontario in 1915 at Point Pelee. Despite numerous surveys, it has not been seen since that time, and very little suitable habitat remains in this and surrounding areas.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable
Criterion C (Small and Declining Number of Mature Individuals): Not applicable
Criterion D (Very Small or Restricted Total Population): Not applicable
Criterion E (Quantitative Analysis): Not applicable

PREFACE

Technically, this is a new report, as it considers the Eastern Tiger Salamander alone for the first time. The Eastern Tiger Salamander, as currently known, was part of the 2001 COSEWIC assessment of the Tiger Salamander (*Ambystoma tigrinum*), which included three separate populations: Great Lakes population (Extirpated), Prairie / Boreal population (Not at Risk), and Southern Mountain population (Endangered). Tiger Salamanders have since been recognized as two separate species, Eastern Tiger Salamander (*Ambystoma tigrinum*) and Western (=Barred) Tiger Salamander (*Ambystoma mavortium*). COSEWIC has recognized two different populations of the Eastern Tiger Salamander, each of which has received a separate designation. The Carolinian population was assessed as Extirpated in November 2012, and the Prairie population was assessed as Endangered in November 2013. Both populations are included in this status report.

No Aboriginal Traditional knowledge for the Eastern Tiger Salamander was available at this time.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2013)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment Canada / Environnement Canada
Canadian Wildlife Service / Service canadien de la faune

Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

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Eastern Tiger Salamander
Ambystoma tigrinum

Prairie population
Carolinian population

in Canada

2013

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

The Tiger Salamander, *Ambystoma tigrinum* (Family Ambystomatidae), was initially described by Green (1825). Because of the extent of geographic variation in colour pattern among tiger salamanders, *A. tigrinum* had been considered a polytypic species with a geographic range spanning most of North America (Bishop 1943; Gehlbach 1967; Brunton 1998). The Eastern Tiger Salamander was considered to be one of its six subspecies: *A. t. tigrinum*. Genetic evidence based on mitochondrial DNA variation (Shaffer and McKnight 1996), as well as morphological evidence (Irschick and Shaffer 1997), indicates that the Eastern Tiger Salamander is a separate species from other tiger salamanders (Powell *et al.* 1998). The tiger salamanders other than the Eastern Tiger Salamander are now collectively recognized as the Western (= Barred) Tiger Salamander, *A. mavortium*, consisting of five subspecies (Crother 2012). The Gray Tiger Salamander, *A. m. diaboli*, which occurs on the Canadian prairies west of the Red River in Manitoba and Saskatchewan is one of these subspecies. Much of the older scientific literature on tiger salamanders does not necessarily distinguish Eastern Tiger Salamanders from what are now known as Western Tiger Salamanders, leading to considerable confusion in interpreting the information.

There is no evidence concerning possible hybridization between Eastern Tiger Salamanders and Gray Tiger Salamanders in Manitoba. There is a 30 km gap between any records of Eastern Tiger Salamanders in Manitoba and the nearest record of tiger salamanders to the west. On the other hand, the transition zone between Eastern Tiger Salamanders and Barred Tiger Salamanders, *A. m. mavortium*, in Missouri, Kansas and Nebraska was found to feature appreciable allozyme and mtDNA sequence differentiation between the two forms, indicating that they evolved in allopatry (Routman 1993).

Morphological Description

Eastern Tiger Salamanders (Figure 1) are robust mole salamanders and are among the largest terrestrial salamanders in North America. Males reach a total length of about 20 cm (Bishop 1943), but Smith (1949) recorded an Eastern Tiger Salamander measuring 33 cm in total length. Male and female Eastern Tiger Salamanders differ only slightly; females are generally smaller and have shorter, less laterally compressed tails and shorter vents (Howard 2009). The male's vent swells during the breeding season (Pope 1964). Adults are primarily dark olive to dark brown or black with irregular greenish to yellow spots on the back and sides (Dunn 1940; Pope 1964; Vogt 1981; Petranka 1998).

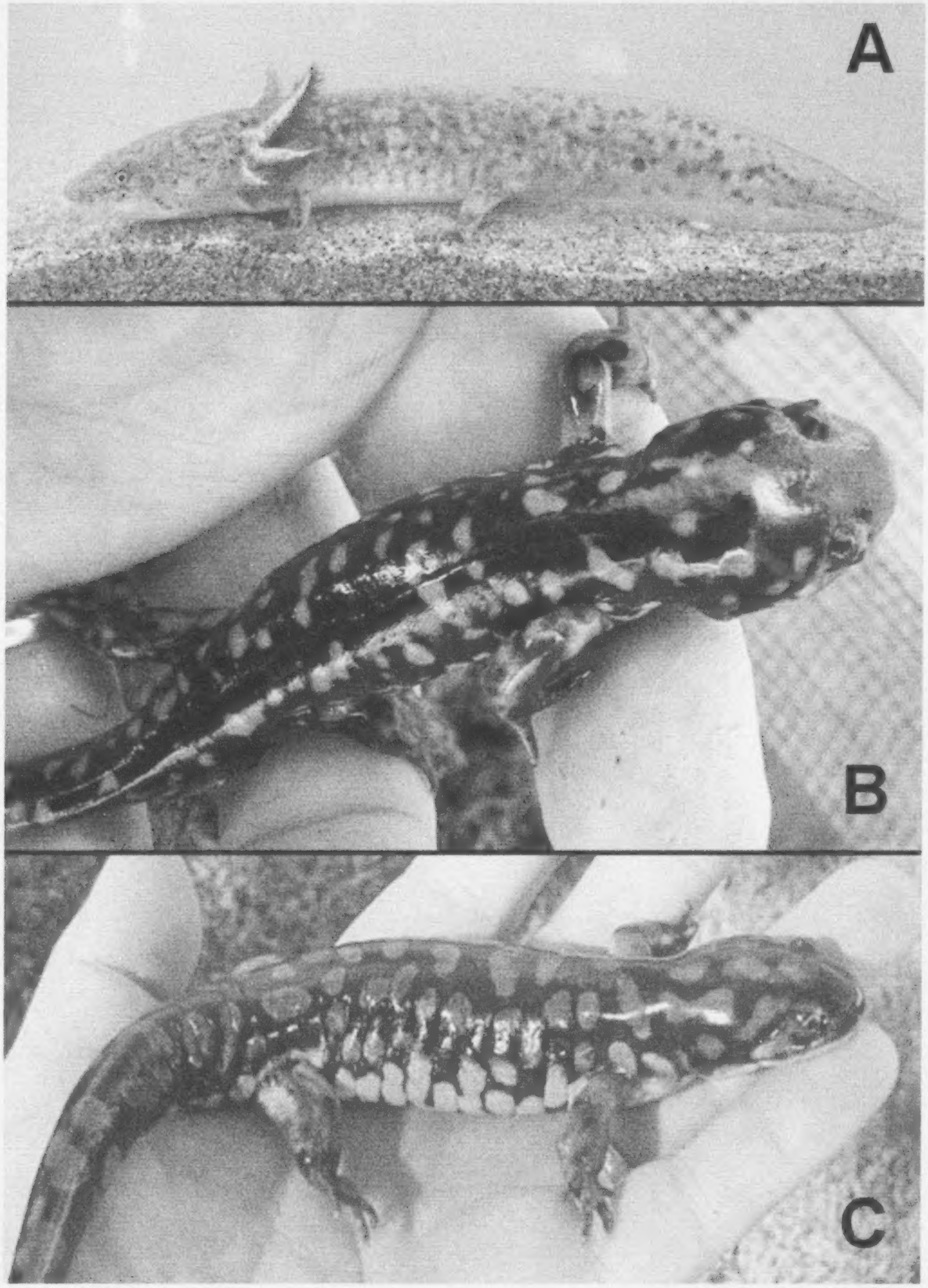

Figure 1. Eastern Tiger Salamanders. A) Larva; B) Juvenile; C) Adult. All photos: from the vicinity of Gardenton, Manitoba, by Doug Collicutt, NatureNorth.com.

Eastern Tiger Salamanders might be confused with Spotted Salamanders, *Ambystoma maculatum*, which are also robust, dark mole salamanders with yellow spots. However, the spots of Eastern Tiger Salamanders are neither as round and distinct nor as restricted to the back as are the spots of Spotted Salamanders. Also, the head of Eastern Tiger Salamanders is rounder in dorsal view, the eyes are relatively small, and the belly is dark with yellow blotches rather than plain grey (Petranka 1998).

Adult Eastern Tiger Salamanders (Figure 1) and Gray Tiger Salamanders, a subspecies of the Western Tiger Salamander (Figure 2), both occur in Manitoba but are distinguishable by colour pattern, which was the basis for former subspecies designations, originally proposed by Dunn (1940). Whereas terrestrial Eastern Tiger Salamanders have yellowish spots on a dark background, Gray Tiger Salamanders can best be described as having black reticulations or spots on a grey background. The differences are apparent in both juveniles and adults.

Newly hatched larval Eastern Tiger Salamanders are silvery grey and 13 – 17 mm in total length, with three pairs of conspicuous, feathery external gills and a broad dorsal fin membrane (Bishop 1941, 1943). Older larvae tend to be dark olive-grey and sometimes have a greenish sheen along the outer surface of the gills. During metamorphosis, larvae begin to develop adult colour pattern and resorb their gills and fin membranes. Recently metamorphosed individuals often have a thin, dark mid-dorsal line where the dorsal fin membrane was resorbed (Schock 2001). The larvae of Eastern Tiger Salamanders may be difficult to distinguish from those of Gray Tiger Salamanders but they are generally more mottled (Figures 1 and 2) and tend to have fewer gill rakers (Collins *et al.* 1980). Eastern Tiger Salamander larvae average 17 gill rakers (range: 13 – 21), whereas Gray Tiger Salamander larvae average 20 gill rakers (range: 18 – 24). Newly hatched larvae of both species of tiger salamanders differ from other species of *Ambystoma* by their lack of balancers, which are small lateral protrusions beneath each eye. Older larvae of both species of tiger salamanders can usually be distinguished from other *Ambystoma* by their flattened, rather pointy toes and large size (Petranka 1998).

Figure 2. Gray Tiger Salamanders, *Ambystoma mavortium diaboli*. A) Larva (photo: Henry Martens). B) Juvenile. Saskatoon, Saskatchewan (photo: Danna Schock). C) Adult. Oak Hammock Marsh, Manitoba (Photo: Doug Collicutt, NatureNorth.com).

Cannibal morph larvae have been reported rarely in Eastern Tiger Salamanders (Gehlbach 1967; Lannoo and Bachmann 1984). Cannibals have very broad flat heads and enlarged vomerine teeth, and specialize in catching and eating other salamander larvae, including individuals nearly as large as themselves (Schock 2001).

Neoteny is rare in Eastern Tiger Salamanders (Gehlbach 1967) but has been reported in rare instances from populations in Michigan, Wisconsin, and Illinois (Hensley 1964; Collins *et al.* 1980; Jones *et al.* 1993; Lannoo 2005), where they reside in permanent bodies of water without predatory fish. Neotenic individuals are those that reach sexual maturity without transforming into a terrestrial form; they are, effectively, permanent larvae.

Population Spatial Structure and Variability

Nothing is known about the spatial structure or variability of Eastern Tiger Salamander populations in Canada. Known occupied sites in Manitoba are separated by relatively large distances (5.6 km – 41 km between sites) within largely agricultural landscape and isolated from one another. These distances are large in light of the movement capabilities of tiger salamanders; the longest recorded movements are in the range of few hundred metres (see **Dispersal and Migration**). It is possible that the Manitoba population is severely fragmented based on the isolation of the sites, lack of recent records from all but one or possibly two sites, and habitat trends, but information is lacking. The landscape in the vicinity of Gardenton, where there are recent records from 1 of 2 sites, and Tolstoi is partially natural, and includes the protected Manitoba Tall Grass Preserve (2,200 ha), which might facilitate movements of salamanders within the landscape.

Church *et al.* (2003) identified two major clades within the range of the Eastern Tiger Salamander, divided by the Appalachicola River and Appalachian Mountains. The western clade is further bifurcated into a southern group on the Gulf Coastal Plain and a northern group including populations from Tennessee, Missouri, Michigan, Wisconsin and Minnesota. Canadian populations of Eastern Tiger Salamanders in both Ontario and Manitoba would belong to this northern group of the western clade and would have entered Canada separately via the tallgrass prairie biome into southeastern Manitoba, and via the Prairie Peninsula (Transeau 1935; Bakowsky and Riley 1993) into southern Ontario (Hecnar *et al.* 2002).

Genetic differentiation among Eastern Tiger Salamander populations within Canada cannot be evaluated. J.P. Bogart used samples of Eastern Tiger Salamanders from near Roseau River, Manitoba, (ROM 16029, 16031 – 36, 16038 – 42; Appendix 1), from Tennessee (ROM 16791 – 96), and from Missouri (ROM 16785 – 90) in a preliminary genetic analysis in 2001. Variation in isozymes and a 302 base-pair portion of the mtDNA genome were unclear. This level of analysis is not considered adequate by today's standards, and all data and genetic samples have subsequently been lost (Bogart pers. comm. 2011). Genetic assessment of the single known Ontario specimen (CMNAR 623), preserved since 1915, is impossible using currently available techniques. As such, the absence of evidence of genetic variation should not be interpreted as evidence of absence of genetic variation.

Designatable Units

Eastern Tiger Salamanders in southern Ontario and southeastern Manitoba occur in the Carolinian and Prairie ecozones, respectively. They represent separate postglacial range expansions into Canada. Their great geographic separation may have resulted in the evolution of differing environmental adaptations, though as prairie habitats were lost in Ontario, Eastern Tiger Salamander habitat would have disappeared as well.

The Manitoba Eastern Tiger Salamanders are discrete from the Ontario Eastern Tiger Salamanders due to the different eco-geographic regions in which they occur and may reflect historical distinction and different sets of adaptations. Further, the loss of the Manitoba populations of Eastern Tiger Salamander would result in an extensive range contraction and loss of the species in Canada. For this reason, Eastern Tiger Salamanders are separated into two designatable units (DUs): the Prairie DU and the Carolinian DU.

Special Significance

Eastern Tiger Salamanders are common in the pet trade (Purser 2001) and popular because of their relatively large size and striking colouration, and the ease with which they can be maintained. Otherwise, Eastern Tiger Salamanders receive little public appreciation.

DISTRIBUTION

Global Range

Eastern Tiger Salamanders have a large, though disjointed range in eastern North America (Figure 3). They occur along the Gulf Coastal Plain from eastern Louisiana to northern Florida and east of the Appalachians up the Atlantic Coastal Plain to Long Island in New York. There is a large, disjunct portion of the range in east Texas and southeast Oklahoma. North and west of the Appalachians, Eastern Tiger Salamanders range from Tennessee, western Kentucky and northern Arkansas through to Indiana, much of Lower Michigan and, barely, into southern Ontario, much of Wisconsin and northward through Minnesota to extreme southeastern Manitoba (Conant and Collins 1998; Petranka 1998). Although Petranka (1998) shows the range of Eastern Tiger Salamanders in Minnesota reaching into northwestern Ontario, there are no Ontario records from that vicinity. Eastern Tiger Salamanders were reported from Ohio's South Bass and Middle Bass Islands between 1940 and 1966 (Langlois 1964; Downs 1989; King *et al.* 1997) but appear to have been eliminated from these islands due to habitat destruction (Downs 1989; King *et al.* 1997; Ngo *et al.* 2009).

Canadian Range

Canadian records of Eastern Tiger Salamanders are known only from southeast Manitoba and extreme southern Ontario (Figure 3).

Manitoba:

The status of Eastern Tiger Salamanders in Manitoba has a history of uncertainty due to both a lack of surveys and the previous practice of cataloguing both Eastern Tiger Salamanders and Gray Tiger Salamanders as the same species. Bishop (1943), without presenting any evidence, mapped the occurrence of tiger salamanders all across southern Manitoba, but ascribed them to the subspecies *diaboli*, the Gray Tiger Salamander. In Conant's (1958) field guide, only Gray Tiger Salamanders were depicted as occurring in southwest Manitoba, and Eastern Tiger Salamanders were not considered to cross the US-Canada border. Logier and Toner (1961) likewise depicted only the Gray Tiger Salamander as occurring in Manitoba. In 1969, though, specimens identifiable as Eastern Tiger Salamanders were collected the area around the town of Roseau River, Manitoba, by K. W. Stewart and deposited in the collection of the University of Manitoba (Preston 1982). Additional adult and larval Eastern Tiger Salamanders were also collected from the Roseau River area in 1970 (CMNAR 12182, 12198 and 30016).The range map in the second edition of Conant's field guide (Conant 1975), indicating Eastern Tiger Salamanders in extreme southeast Manitoba, is likely based on these specimens. Preston (1982) specifically commented on the colouration of the University of Manitoba specimens.

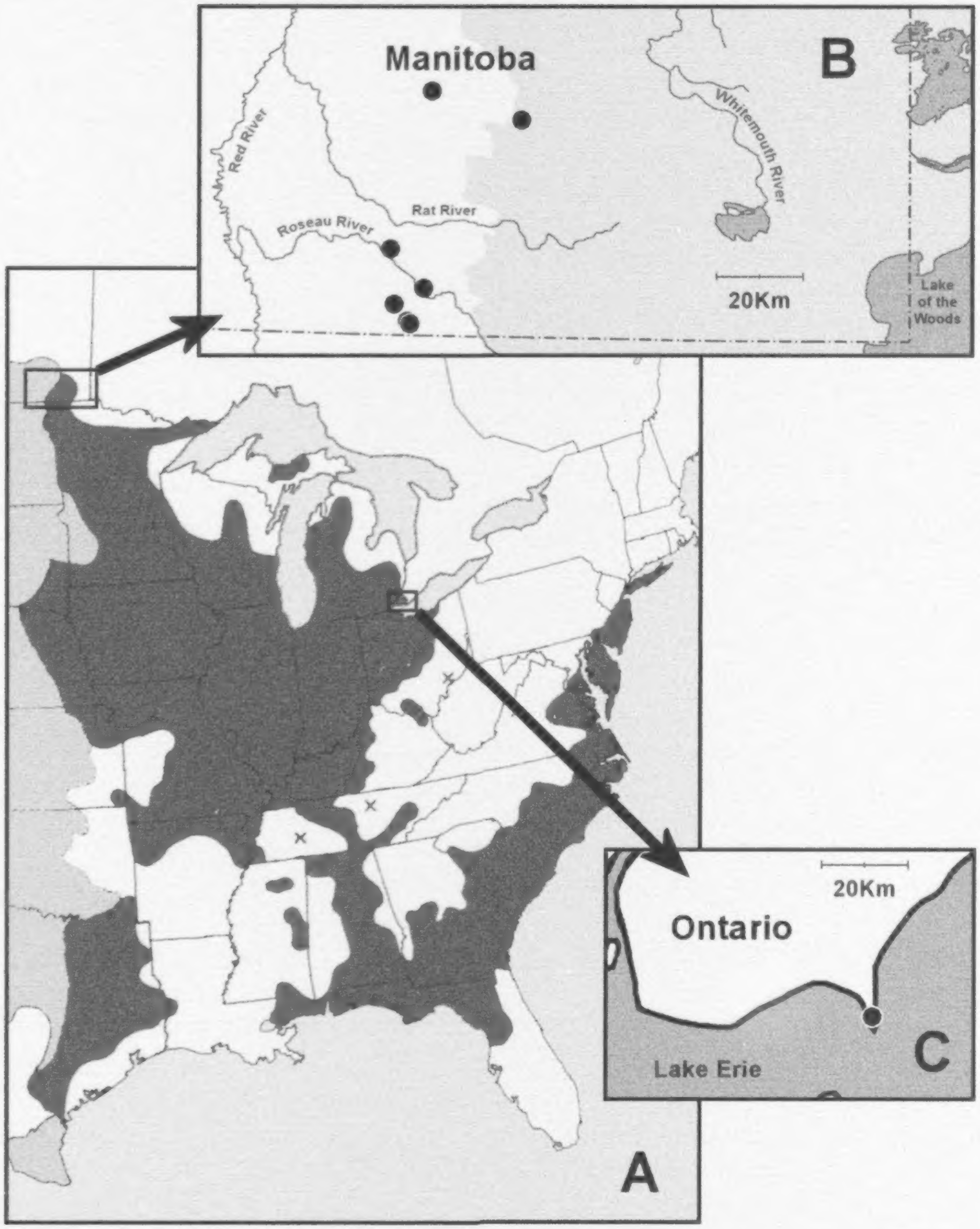

Figure 3. Geographic range of the Eastern Tiger Salamander and known localities within Canada. A. North American range (dark blue). Isolated records are indicated with an "x". The range of the related western species, the Western Tiger Salamander, is depicted in dark grey (adapted from Petranka 1998). B. Southeastern Manitoba showing confirmed localities (black dots) and the extent of prairie and partially forested habitat (white) versus more densely forest habitat (shaded green). For more details on terrestrial ecozones, see Appendix 2. C. Extreme southwestern Ontario showing approximate site of the only known locality from the area, at Point Pelee (black dot).

There are only a few other records of Eastern Tiger Salamanders from Manitoba. Egg masses collected near Tolstoi and Roseau River in 1985 by L. Lowcock were raised through metamorphosis, and subsequently identified as Eastern Tiger Salamanders (Appendix 1). A single specimen (Manitoba Museum, MM 375), collected in 1987 by J. Dubois and M. Oberpichler southwest of Gardenton, is upon examination clearly an Eastern Tiger Salamander, although it was incorrectly identified at the time by W.B. Preston as Gray Tiger Salamander. In 1990, Preston, in his field notes archived with the Manitoba Museum of Man and Nature, noted large salamanders with yellow spots "possibly eastern tiger salamanders" in the vicinity of Marchand, Manitoba. The most recent records of Eastern Tiger Salamanders in Manitoba are observations in 2011 southwest of Gardenton by D.C. Collicut and W. Watkins (Appendix 1). Surveys of 30 quarter sections in the vicinity of this observation in 2012 did not locate the species; ponds within all but 7 quarter sections were dry that year (Watkins pers. comm. 2013). Two landowners whose ponds were dry in 2012 reported seeing adult salamanders in August in previous years. There is also an anecdotal observation of salamanders from a residential garden in Tolstoi in August of recent years, although the resident reported not having seen them over past several years (Watkins pers. comm. 2013).

Four specimens collected between 1884 and 1888 by W.S. Ducker (ROM 1248, 3941, 3967 and 3977) are catalogued in the Royal Ontario Museum as "*Ambystoma tigrinum diaboli*" from "Shoal Lake". "Shoal Lake" most likely refers to the town of Shoal Lake located in southwestern Manitoba, well within the range of Gray Tiger Salamanders, and not to the Shoal Lake of extreme eastern Manitoba and adjacent Ontario where tiger salamanders are highly unlikely to occur.

There are no records of either Eastern Tiger Salamanders or Gray Tiger Salamanders in Manitoba in the approximately 30 km stretch between the towns of Roseau River or Tolstoi and the Red River, aside from a single specimen in the Manitoba Museum of a tiger salamander (MM 380) from just outside Emerson, which is located on the east bank of the Red River. The specimen is, however, in poor condition and shows signs of having once dried out completely. Though it is identifiable as a tiger salamander, it is not possible to determine if it is an Eastern Tiger Salamander or a Gray Tiger Salamander. All museum specimens of tiger salamanders examined from west of the Red River in Manitoba are Gray Tiger Salamanders.

Southern Ontario:

Eastern Tiger Salamanders are known from southern Ontario by a single, adult specimen (CMNAR 6233) collected by P.A. Taverner on October 2, 1915, at "Point Pelee" (Logier 1925; Logier and Toner 1961). Morphologically, the specimen is clearly a tiger salamander (Figure 4), but the lack of any other evidence of Eastern Tiger Salamanders in southern Ontario is puzzling. Ngo *et al.* (2009) argued at great length that the Taverner record is unreliable, in part because the specimen, as it was preserved in formalin, cannot be genetically tested. Ngo *et al.* (2009) also argue that the absence of any tiger salamander genomes in the polyploid mole salamanders of the Jefferson Salamander (*Ambystoma jeffersonii*) complex on either the Ontario mainland or the Canadian islands of western Lake Erie suggests that Eastern Tiger Salamanders are neither present now nor likely present in the past. This, though, is the same evidence used to conclude that Eastern Tiger Salamanders are now completely extirpated from Ontario (Schock 2001). What will remain in some doubt is whether or not Taverner, a respected naturalist intimately familiar with Point Pelee (Taverner 1914; Taverner and Swales 1907 – 1908), actually collected the specimen there as his field notes (Taverner 1915a,b) are not clear about the precise location. Evidence suggesting the Taverner record is valid includes the former presence of Eastern Tiger Salamanders on the adjacent Bass Islands of Ohio. These islands formed part of the post-Pleistocene landbridge connecting Ohio and Michigan with southwestern Ontario (Hecnar *et al.* 2002) and facilitated the entry of "Prairie Peninsula" fauna to Canada (Transeau 1935; Bakowsky and Riley 1993). It would be even more puzzling if no Ontario record for Eastern Tiger Salamanders existed. Ultimately, the specimen, with its associated information, remains the best evidence that Eastern Tiger Salamanders once occurred in southern Ontario; its existence is difficult to argue away whatever doubts there may be about its provenance.

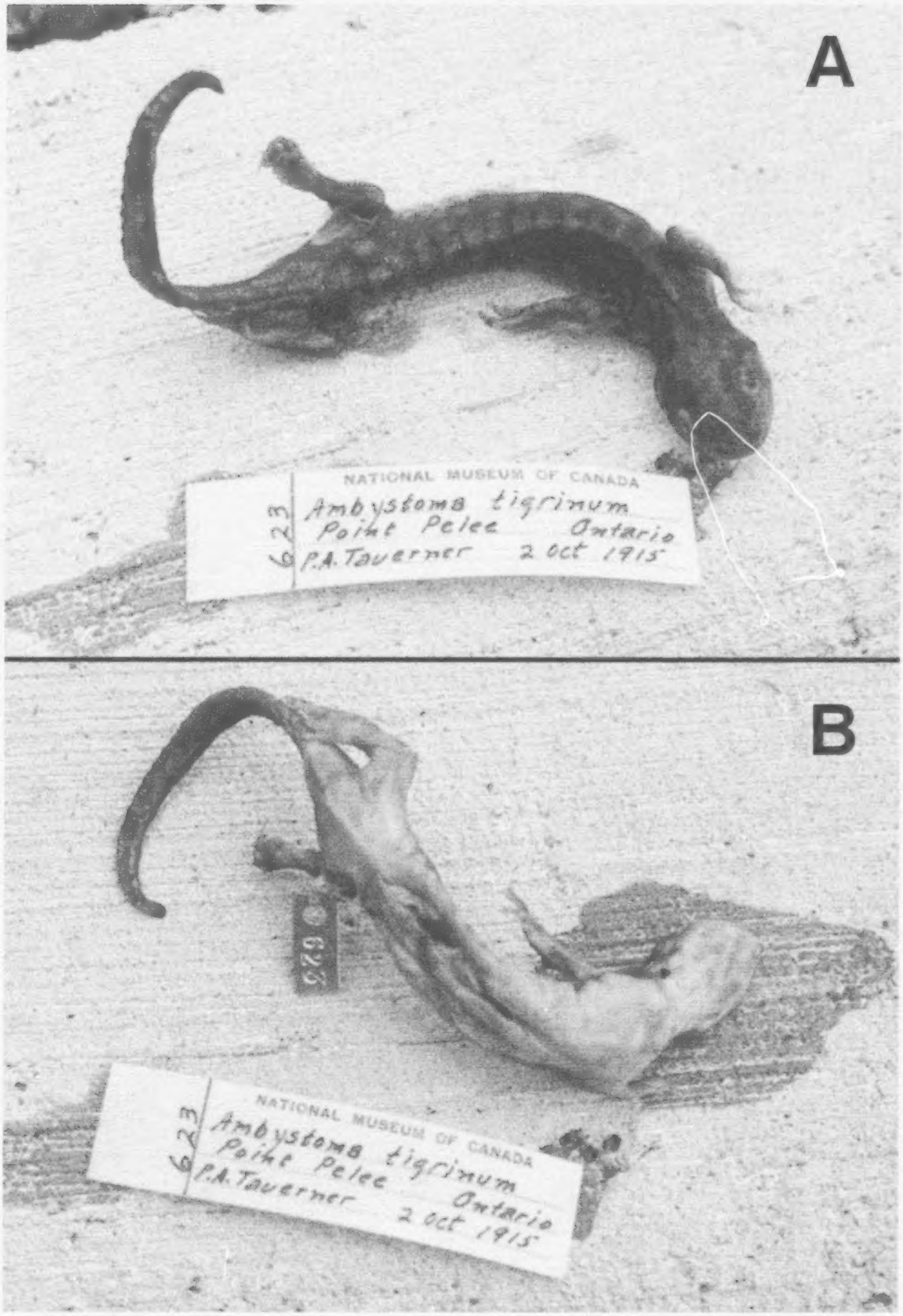

Figure 4. Eastern Tiger Salamander. A) dorsal view. B) ventral view. This is the 1915 specimen collected by P.A. Taverner (CMNAR 623) and reported to have been found at Point Pelee (Logier 1925). The shape of the head, distribution of dorsal spots and mottling of the belly identify it as an Eastern Tiger Salamander. Compare with Figure 1. (Photos: F.R. Cook).

Eastern Tiger Salamanders persist on Kelley's Island, Ohio, in Lake Erie (Downs 1989), which is 11 km south of Pelee Island and 35 km south of Point Pelee, Ontario.

Extent of Occurrence and Area of Occupancy

Based on the records available (Figure 3, Appendix 1), extent of occurrence (EO) for Eastern Tiger Salamanders in Manitoba is approximately 770 km^2 based on a minimum convex polygon. The index of area of occupancy (IAO) in Manitoba is 20 km^2, based on a 2 km x 2 km square grid placed on each of the 5 extant occurrences. An additional historical occurrence (1969, Steinbach) is excluded because the species has not been recorded since and because of extensive habitat loss in the area due to expanding human population.

There are no recent records of the species from Ontario.

Search Effort

There have been no systematic surveys for Eastern Tiger Salamanders in Canada. However, there have been extensive herpetofaunal surveys in Point Pelee National Park over the past century (Taverner 1914; Patch 1919; Logier 1925; Cook 1967; Cook 1971; Rivard and Smith 1973a,b; Damas and Smith Ltd. 1981; Wigle undated; Kraus 1991; Hecnar and M'Closkey 1994, 1995; Oldham and Weller 2000; Ngo *et al.* 2009), and no salamanders of any kind have been found.

In southeastern Manitoba, Eastern Tiger Salamanders were recorded near Gardenton as recently as 2011 by D.C. Collicut (Appendix 1), but no systematic surveys of its likely range have been undertaken. However, targeted surveys for salamanders have been conducted in localized areas. Doug Collicott (pers. comm. 2013) has searched approximately 20 ponds, some repeatedly, for Eastern Tiger Salamanders, targeting habitats deemed best for breeding (approximately 4 days of surveys over the past 3 years). The surveys included searches for egg masses and breeding adults in spring and attempts to find larvae in summer. In 2011, approximately 30 ponds were surveyed in the southern portion of the known range within 45 km of the international border (Watkins pers. comm. 2013). These included a cluster of ponds in the vicinity of Grunthal and several ponds south of St. Malo. In July 2012, summer students with Manitoba Conservation and Water Stewardship Wildlife Branch visited 33 quarter sections with dugouts and natural wetlands in the vicinity of the Gardenton site. No salamanders were found in any of the ponds; however, only 7 quarter sections had ponds with water (Watkins pers. comm. 2013). No surveys were conducted in 2013.

The Manitoba Herps Atlas (undated) shows numerous observations of frogs from southeastern Manitoba. However, these records do not provide a reliable indication of search effort because salamanders are more cryptic than frogs, the presence of which may be confirmed by vocalizations, and can be difficult to locate if not specifically searched for; furthermore, the atlas records include incidental observations by the public.

HABITAT

Habitat Requirements

Eastern Tiger Salamanders inhabit areas where sandy or friable (crumbly) soils surround fishless, semi-permanent or permanent water bodies that they use as breeding sites (Petranka 1998; Lannoo 2005). These aquatic breeding sites are generally soft-bottomed and may or may not have abundant emergent vegetation (Bishop 1943; Smith 1961; Brandon and Bremer 1967; Minton 1972, 2001; Werner and McPeek 1994; Lannoo 1996, 2005). They are typically deeper than those used by other mole salamanders (Downs 1989) and must hold water at least for the 3 – 7 months that it takes for mating, egg laying, hatching, larval development, and metamorphosis. Aquatic, neotenic adults may occur in fishless permanent wetlands.

Terrestrial adult and juvenile Eastern Tiger Salamanders burrow actively into deep friable soils using their forelimbs (Gruberg and Stirling 1972; Semlitsch 1983a) or will make use of abandoned mammal burrows (Duellman 1954; Gehlbach 1967; Collins *et al.* 1993). The one site with recent records of the species near Gardenton is surrounded by a soil type known as the Leary series. These soils have high permeability, moderate surface runoff, and a low water table during the growing season. Leary soils have low water holding capacity, low organic matter content, and low natural fertility. Native vegetation often includes woodlands dominated by Burr Oak (*Quercus macrocarpa*). In Manitoba, the majority of these soil types are currently excavated for road construction and the aggregate industry (Watkins pers. comm. 2013).

Eastern Tiger Salamanders have also been found under rocks, limestone flakes or piles of debris or manure, and may stumble into sewers, drains, cellars, and window wells (Pope 1964; Vogt 1981; Bogart *et al.* 1987). They are somewhat tolerant of agriculture (Steen *et al.* 2006) and are often the most common salamanders within the heavily agricultural Midwest of the United States (Lannoo 2005). However, the type of crop and soil moisture regime greatly influences the suitability of cultivated areas for the salamanders, and the salamanders are better able to use areas with high moisture (Cosentino *et al.* 2011).

Eastern Tiger Salamanders tend to be associated with grasslands, savannas, and woodland edges adjacent to breeding sites, and less so with closed canopy forests (Brodman 2010). The five extant and one extirpated localities of the species in Manitoba occur in the Steinbach Ecodistrict, within the Interlake Plain Ecoregion of the Boreal Plains Ecozone (Smith *et al.* 1998). This ecodistrict occurs as a narrow north-south corridor within southeast Manitoba bounded by the Prairie Ecozone to the west, and the Boreal Shield Ecozone to the east (Appendix 2).

Habitat Trends

In southeast Manitoba where the Eastern Tiger Salamander is found, a transition in land use occurs from intensive annual cropland just east of the Red River (Prairie Ecozone), to areas with increasingly natural habitats toward the east (Boreal Plains and Boreal Shield ecozones). A portion of the range of the Eastern Tiger Salamander, including the Roseau River locality[1], overlaps with the Rat-Marsh River Watershed (218,000 ha), for which an integrated watershed management plan (IWMP) has been prepared (AESB & MAFRI 2011) and for which land use trends have been documented in detail. Three sites (Tolstoi and two Gardenton sites) are immediately to the south in the Roseau River Watershed, for which a watershed plan has been prepared (RRWI 2007). Two sites (Marchand and the extirpated Steinbach sites) are to the north/northeast within the Seine River Watershed, for which an IWMP is also in preparation (SRRCD 2013).

Within the portion of the Rat-Marsh River that overlaps with the Steinbach Ecodistrict (see Appendix 2), where Eastern Tiger Salamander has been found, land cover consists predominantly of grassland and forest, interspersed with wetlands (see Figure 15 in AESB & MAFRI 2011). Agricultural activity in this area is primarily livestock production (hogs, poultry, beef) with minor forage and annual crop production components. Similar land use has been noted in the Roseau River Watershed within Stuartburn Rural Municipality (the latter largely overlaps with the Steinbach Ecodistrict). RRWI (2007) reports that the economic base of that rural municipality is primarily cattle farming and forage crop production.

Within the portion of the Seine River Watershed that overlaps with the Steinbach Ecodistrict, land use consists predominantly of grassland and forest, with lesser but still substantive annual crop and forage crop components. In the vicinity of Steinbach, there is significant urban development (Figure 3 of SRRCD 2013). The most intensive hog industry in Manitoba is located in this watershed.

Aquatic habitat and riparian assessment was conducted along a 262 km stretch of the Rat River and Joubert Creek (Graveline *et al.* 2005), which intersect the Eastern Tiger Salamander's range. Overall, the areas were assessed as moderately to highly impacted by human activities. Poor water quality due to land use practices (including livestock operations) and channel modification is reported in the Roseau River (RRWI 2007). Because Eastern Tiger Salamanders do not use river habitat, the above information represents an indirect indication of habitat quality. Habitat degradation could occur if the same land use practices that have affected waterways impacted the ponds that comprise the salamander's breeding habitat (e.g., if cattle degraded individual breeding ponds in the landscape).

[1] The Roseau River location, unintuitively, is not within the Roseau River Watershed. It lies north of the town of Roseau River, and just inside the adjacent Rat-Marsh River Watershed.

Wetlands were found along 31% of the Rat River (AESB & MAFRI 2011), and this percentage is likely representative of the Steinbach Ecodistrict. The presence of predatory fish in wetlands that are connected to these waterways at least occasionally at high water levels would reduce their suitability for tiger salamanders. Graveline *et al.* (2005) reported 31 species of fish from the Rat River. Three species of trout have been introduced but appear to be rare with last stocking records from 1988.

Fertilizers, herbicides, and pesticides have the potential to pollute tiger salamander breeding sites through runoff from surrounding agricultural lands. The predominant form of agriculture within the Steinbach Ecodistrict is livestock production (see above), so nutrient loading from livestock is likely to be of greatest concern. Annual croplands are a minor component within the ecodistrict, and hence commercial fertilizers and herbicides are likely a lesser threat.

A network of roads is present over the entire range of the species. The 2011 Annual Average Daily Traffic (AADT) for the major roads in the area of the four southern extant sites ranged from 60-1060 (MHTIS 2012), but AADT for rural routes between these roads is most likely smaller as they serve the local population and are not near any larger urban centres. However, even low traffic volume during peak migration periods of the salamanders could result in significant roadkill.The two northernmost Eastern Tiger Salamander sites in Manitoba (Marchand and Steinbach in Appendix 1) are within highly fragmented landscapes with agricultural and residential developments

In southern Ontario, historical loss of wetlands has been extensive. Pre-European settlement in ca. 1800, Essex County is estimated to have had 83.4% wetland cover, which by 1967 was reduced to 2.3%; the losses have continued to current 1.6% wetland cover (Ducks Unlimited 2010). Major habitat loss took place within the 19th century before any biological collecting was conducted. Point Pelee National Park has old field and prairie remnant habitat on sandy soil as well as approximately 325 ha of thicketed, woodland, or forested habitat on friable, sandy soil appropriate for Eastern Tiger Salamanders to burrow into. However, there are no uncontaminated and fish-free wetlands remaining at Point Pelee (Ngo *et al.* 2009), and therefore no suitable breeding wetlands for Eastern Tiger Salamanders.

In the United States, suitable habitat for Eastern Tiger Salamanders is progressively disappearing. In portions of the US Midwest, nearly 99% of breeding wetland habitat has been lost (Leja 1998). Localized habitat for the species directly south of the Manitoba border may exist, but its extent and quality have not been assessed.

BIOLOGY

There have been no studies of the biology of Eastern Tiger Salamanders in Canada, and most that have been done concern populations in the southeast of their range in the US.

Life Cycle and Reproduction

In northern locales, Eastern Tiger Salamanders typically breed in wetlands following spring rains within a few weeks of ice-off (Sever and Dineen 1978; Semlitsch and Pechmann 1985; Lannoo 1996; Williams *et al.* 2009). This usually takes place in March in Iowa (Lannoo 1996), earlier in more southern and coastal areas and later in more northern areas (Bishop 1941; Peckham and Dineen 1954; Brandon and Bremer 1967; Hassinger *et al.* 1970; Anderson *et al.* 1971; Morin 1983; Semlitsch 1983a; Lannoo and Bachmann 1984; Downs 1989; Trauth *et al.* 1990). In the southeast US, though, they breed after rains in the autumn (Semlitsch 1983b).

Males tend to outnumber females at breeding sites, with reported male:female ratios ranging from 1:1 to 5.3:1 (Peckham and Dineen 1954; Sever and Dineen 1978; Semlitsch 1983a). After a brief courtship (Kumpf 1934; Arnold 1976), the male deposits a spermatophore (sperm packet) on the bottom of the pond which the female picks up with her cloaca. Both sexes engage in multiple matings (Williams and DeWoody 2009). Shortly after mating, females attach clusters of darkly pigmented eggs to twigs or stems of emergent plants, 30 cm or more below the surface of the water (Englehardt 1916; Bishop 1943; Stine *et al.* 1954; Sever and Dineen 1978; Couture and Sever 1979; Morin 1983; Trauth *et al.* 1990). Clutch sizes from individual females were between 250 – 350 ova in New Jersey (Anderson *et al.* 1971), averaged 421 ova in Michigan (Wilbur 1977) and averaged 624 ova in Illinois (Tucker 1999), but females frequently partition their clutches into multiple discrete egg masses, each of which may contain 18 – 110 eggs (Anderson *et al.* 1971; Gopurenko *et al.* 2006). The average cluster of eggs measures approximately 5.5 cm by 7 cm (Pope 1964; Vogt 1981; Petranka 1998).

The time from hatching through transformation to the terrestrial form varies depending on food availability, climate, density, and pond hydroperiod. Eggs require 19 to 50 days to incubate, depending on water temperature (Enge and Stine 1987). Populations in New York, Michigan and Indiana take 2 to 3½ months to metamorphose (Ruthven *et al.* 1928; Bishop 1941; Wilbur and Collins 1973; Sever and Dineen 1978; Petranka 1998), though Eastern Tiger Salamander larvae may also overwinter in permanent ponds before transforming (Brandon and Bremer 1967). Tiger salamander larvae grow faster than larvae of all other *Ambystoma* species (Keen *et al.* 1984; Petranka 1998).

The demographics of Eastern Tiger Salamander populations are not fully understood. Egg and larval mortality rates are highly variable (Church *et al.* 2007) and sometimes exceed 80% (Sever and Dineen 1978). Anderson *et al.* (1971) calculated survival from egg to metamorphosis to be 3.3% at a site in southern New Jersey. Survival to first reproduction also appears to be low. Semlitsch (1983b) reported that of 1041 new metamorphs that left one isolated breeding site, only 6 returned one year later and only 52 returned 2 years later when individuals in that population were thought to reach sexual maturity. Time to sexual maturity also appears to vary from population to population, based on climate and genetic factors (Lannoo 2005), with males generally reaching sexual maturity in 2 years and females in 3 to 5 years (Wilbur and Collins 1973; Semlitsch, 1983, Petranka 1998). Females may defer reproduction in years of drought (Church *et al.* 2007). The longevity record for an Eastern Tiger Salamander in captivity is 16 years (Petranka 1998), but survival in the wild is certainly less than that.

Bailey *et al.* (2004) estimated that the probability of a male Eastern Tiger Salamander returning to breed in successive years was only 20 – 30%, based on four years of data from a population in Augusta Co., Virginia, where the species is listed as endangered. This estimation of survival would give an average age of adults (i.e., generation time) of approximately 2.2 – 2.4 years. However, Church *et al.* (2007) estimated mean survival probability among three ponds in the same region over four years to be 85% for females and 75% for males, yielding average ages of 6.2 years for females and 4.8 years for males. Nevertheless, there was considerable year-to-year variation in survivorship related to amount of rainfall. In one pond, the survival rate of adult females was estimated to be 100% in one year and only 55% the following year. In view of this variability, and the evidence of greater longevity among females, overall average ages of about 3.5 years for males and 5 years for females may be inferred.

Dispersal and Migration

To reach their breeding sites, terrestrial adult Eastern Tiger Salamanders migrate from overwintering sites (Sever and Dineen 1978; Vogt 1981; Semlitsch and Pechmann 1985). Males migrated 2 – 8 weeks earlier than females at the Savannah River site in South Carolina (Semlitsch 1983a), though Peckham and Dineen (1954) and Williams *et al.* (2009) reported that males and females arrived at about the same time at an Indiana site.

Following the breeding season, adults return to their terrestrial habitats (Hassinger *et al.* 1970; Sever and Dineen 1978; Vogt 1981; Semlitsch and Pechmann 1985; Petranka 1998). Steen *et al.* (2006) tracked Eastern Tiger Salamanders in Georgia that had moved up to 255 m from their breeding pond, whereas Madison and Farrand (1998) found that radio-tracked individuals on Long Island frequently used habitat as far as 300 m from their breeding pond. Semlitsch (1980, 1983b) found evidence that in South Carolina Eastern Tiger Salamanders return preferentially to the same ponds year after year. Church *et al.* (2007) found that movement of individuals among populations in Indiana was extremely low. Movements of Eastern Tiger Salamanders through agricultural fields are differentially affected by the type of crop as salamanders are better able to deal with fields in which the crops, such as soy-beans, maintain relatively high soil humidity than in fields with crops that engender low soil humidity (Cosentino *et al.* 2011).

Once they have metamorphosed, juveniles leave natal ponds and migrate to their terrestrial habitat, though they may still be found at the margins of the pond for some time (Kraus 1985; Bogart *et al.* 1987; Petranka 1998).

Interspecific Interactions

Eastern Tiger Salamanders are visually oriented “sit and wait” predators. Aquatic larvae and neotenes primarily consume aquatic invertebrates including amphipods, molluscs, insect larvae, and copepods, as well as tadpoles, small frogs and other salamanders (Dobie 1962; Dodson and Dodson 1971; Brophy 1980; Lindquist and Bachmann 1980).

Eastern Tiger Salamanders may be important predators of aquatic and forest floor invertebrates, as well as opportunistic predators of small vertebrates. Terrestrial juveniles and adults feed on a variety of small prey such as earthworms, molluscs, and insects including crickets, grasshoppers, moths, flies, beetles and cicadas, as well as spiders, small mice and voles, frogs, and other salamanders (Bishop 1941; Pope 1964; Petranka 1998).

Eastern Tiger Salamanders, in turn, serve as prey for predators larger than themselves, including many species of predaceous fishes and invertebrates, garter snakes (*Thamnophis* spp.), and crows (Sprules 1972; Collins and Wilbur 1979; Vogt 1981; Petranka 1998). Terrestrial adults will assume a defensive posture by raising their hind legs and arching and waving their tail (Brodie 1977; Smith 1985). As with other *Ambystoma* species, they have granular skin glands along the dorsal surface of the tail which produce noxious and sticky secretions (Brodie 1983; Hamning *et al.* 2000).

Predation on eggs by Eastern Newts (*Notophthalmus viridescens*) can be sufficient to exclude Eastern Tiger Salamanders from wetlands (Morin 1983; see also Petranka 1998). Nevertheless, Eastern Newts and Eastern Tiger Salamanders have been reported to co-exist in southern Illinois (Brophy 1980).

The presence of Eastern Tiger Salamander larvae lowers the survival of larvae of Blue-spotted Salamanders, *Ambystoma laterale,* and Small-mouthed Salamanders, *A. texanum*, where they co-occur in the US (Lannoo 2005).

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

There is no information on Eastern Tiger Salamander population sizes and trends in Canada. In southern Ontario, there is no population of the Eastern Tiger Salamander to investigate.

Abundance

Breeding populations of Eastern Tiger Salamanders are known to vary in size, depending largely on larval survival (Pechmann *et al*. 1991). An Indiana population was estimated to consist of 1,100 to 2,000 adults (Peckham and Dineen 1954; Sever and Dineen 1978), and 540 breeding adults were counted in a New Jersey population (Hassinger *et al*. 1970; Anderson *et al*. 1971). Pechmann *et al*. (1991) and Semlitsch *et al*. (1996) observed the number of breeding adults entering Rainbow Bay in South Carolina to vary by as much as one order of magnitude from one year to the next.

The abundance of Eastern Tiger Salamanders in southern Ontario can safely be estimated to be zero; their abundance in southeastern Manitoba is unknown.

Fluctuations and Trends

There are no recent records of Eastern Tiger Salamanders from southern Ontario. Recent searches for Eastern Tiger Salamanders in southeastern Manitoba (Appendix 1) have served only to reconfirm their presence in the vicinity of Gardenton, and no estimates of their abundance have been undertaken. Because of this lack of specific information, fluctuations and trends cannot be directly estimated for Canadian populations but their likelihood can be inferred from results obtained from populations elsewhere.

Pond-breeding amphibians, in general, are prone to large fluctuations in abundance (Green 2003), and these have been regularly observed in long-term studies of Eastern Tiger Salamander populations (Pechmann *et al.* 1991; Semlitsch *et al.* 1996). In South Carolina, studies of Eastern Tiger Salamander demographics over longer time-frames by Hairston (1987), Pechmann *et al.* (1991), Semlitsch *et al.* (1996) and Daszak *et al.* (2005) provide increasingly strong evidence of extreme variations in abundance of breeding females and post-metamorphic juveniles. Although Hairston (1987) noted a 5.5-fold level of variation in the number of breeding females over a four-year period, Pechmann *et al.* (1991) documented a 90-fold level of variation over 12 years. Over 16 years of studies at Rainbow Bay, South Carolina, Semlitsch *et al.* (1996) found the numbers of breeding females to range from 0 to 92 and numbers of emerging post-metamorphic juveniles to range from 0 to 1,041. In 10 of those 16 years, recruitment of juveniles was either 0 or negligible. Over 25 years of study, Daszak *et al.* (2005) found 0 females breeding in 9 of those 25 years and 17 of 25 years with zero juvenile recruitment. This behaviour results in a pulsed pattern of breeding success among years, subsequently resulting in similar pulses of recruitment of young into the adult population.

As Church *et al.* (2007) found in the Shenandoah Valley of Virginia, female Eastern Tiger Salamanders may defer breeding in unfavourable conditions, especially during periods of drought. Deferral of breeding may be a viable reproductive strategy for females provided their annual survivorship is high. In populations with lower annual survivorship, such as the one studied by Bailey *et al.* (2004), the trade-off between reproductive success and survival may not favour deferral of breeding. In the harsher environment of the northern limit to the species' range, where the prospect of winter kill may be significant, it may be doubtful that deferring reproduction is a successful strategy. Years of zero recruitment, therefore, may further contribute to large fluctuations in abundance (Semlitsch *et al.* 1996).

In the US, Eastern Tiger Salamanders have plummeted in abundance in the Midwest compared with historical levels (Lannoo 1996, 2005). Semlitsch *et al.* (1996) demonstrated a comparable decline at the Savannah River site in South Carolina during the 1980s and early 1990s. As with many amphibian species that breed in semi-permanent wetlands, larval Eastern Tiger Salamanders may experience mass mortalities associated with pond drying (Sever and Dineen 1978; Lannoo 1998a). Complete recruitment failures in Eastern Tiger Salamanders were caused by earlier than usual pond drying in five of the last six years of Pechmann *et al.*'s (1991) 12-year study in South Carolina. Where they occur, aquatic, neotenic adults are particularly threatened during droughts (Lannoo 2005). At Rainbow Bay, at the Savannah River site, Semlitsch (1983b) found that Eastern Tiger Salamanders required longer hydroperiods for successful aquatic development than any other local amphibian species. Daszak *et al.* (2005) later demonstrated that the decline of Eastern Tiger Salamanders at the site has likely been due to an increase in the number of years with insufficient rainfall to maintain breeding pond hydroperiod for a sufficient length of time. On the Canadian prairies, including southern Manitoba, several changes in the region's climate have been observed over the past 50 years, including an increase in average temperature, a decrease in snow cover and an increase in the number of days over 30°C (Kulshreshtha 2011), all of which have been related to increased frequency and severity of drought (Sauchyn *et al.* 2005).

Rescue Effect

As there is, at present, no suitable habitat for Eastern Tiger Salamanders in southern Ontario (Ngo *et al.* 2009), there is no prospect of rescue for them. The permanent ponds in the Point Pelee National Park marsh are, and probably always have been, occupied by a broad array of fish species (47 species recorded to date), including many that are predatory (Surette and McKay 2007). In addition, exotics like the Goldfish (*Carassius auratus*) have become established, likely through introductions by the public. However, ongoing prairie restoration efforts hold promise to improve habitat that might be suitable for Eastern Tiger Salamanders in southern Ontario (Hecnar pers. comm. 2011).

Whereas there may be suitable habitat for Eastern Tiger Salamanders in southeast Manitoba, the status of populations in adjacent Minnesota is unknown. The nearest museum record is from Bemidji, Minnesota, some 250 km east-southeast of Roseau River, Manitoba. Minnesota Department of Natural Resources (2012) online map shows additional post-1960s records of Eastern Tiger Salamanders from northwestern Minnesota (vouchers not examined for this report).

THREATS AND LIMITING FACTORS

Like most amphibians with biphasic life-histories and separate habitat requirements for adults and larvae, Eastern Tiger Salamanders must contend with threats and limitations in both aquatic and terrestrial habitats in an increasingly modified and urbanized environment (Hamer and McDonald 2008). None of this is known specifically for Eastern Tiger Salamanders in Canada but may be surmised from habitat trends and information available for US populations. Loss or degradation of both the terrestrial and aquatic habitats required by Eastern Tiger Salamanders, as well as migration routes between these habitats, are expected to have detrimental effects upon the long-term persistence of salamander populations (Schock 2001). Although Vogt (1981) indicates that urbanization and agricultural activity do not always result in the extirpation of Eastern Tiger Salamanders from an area, housing and agricultural developments bring increased traffic, wetland conversion and land clearing, which are the chief drivers of habitat loss (Berger 1989; Bence and Howard 1990). According to Leja (1998), in portions of the US Midwest, European settlement has resulted in the loss of nearly 99% of pre-existing wetland habitat that could have been used by Eastern Tiger Salamanders, and other amphibians, for breeding.

Results from IUCN threats calculator assessment (Master *et al.* 2009), based on expert opinion and examining habitat trends, indicate that the greatest threats to the Manitoba population are from habitat modification from agricultural activities, roadkill, water management, pollution of breeding sites, and multi-year droughts associated with climate change (Appendix 3). Invasive and other problematic species, including fish and disease-causing organisms, contribute to the threats. The overall threat impact was rated as "very high" to "high". The following narrative focuses on threats to the Manitoba population, although the same general threats apply to the species as a whole; the Point Pelee population in Ontario is mentioned only where specific information exists.

Agriculture

In southeast Manitoba, Eastern Tiger Salamanders exist within landscapes used primarily for livestock raising, pasture, and forage crops (see **Habitat Trends**). Conversion of habitats to agricultural lands is largely historical, but activities such as cattle grazing continue to affect salamanders and their habitats. Although terrestrial habitats may be degraded by heavy grazing or other agricultural activities, the main impacts are probably on aquatic breeding sites. There is a tendency to minimize buffers around ponds and wetlands to increase arable land. On pastures, cattle can deteriorate shallow-water areas of ponds and their margins that form important habitat for salamanders. Not all effects of cattle are negative. Dugout watering holes may provide habitat for salamanders, provided they are not stocked with fish, and grazing may help retard forest encroachment onto grasslands.

Transportation and Service Corridors

Because Eastern Tiger Salamanders migrate to and from breeding ponds, they are susceptible to road mortality where roads separate overwintering sites from breeding ponds (Duellman 1954; Conant and Collins 1998). Amphibian populations have been shown to decrease in size with increasing traffic volume (Fahrig *et al.* 1995). Duellman (1954) found that among 274 Eastern Tiger Salamanders found on a 3.54 km stretch of highway in Michigan, only 46 were alive and the rest had been run over by automobiles. Patch and Stewart (1924) and Clevenger *et al.* (2001) documented significant roadkill of Western Tiger Salamanders at Ninette, Manitoba, and Kananaskis, Alberta, respectively. An extensive network of roads is present within the Eastern Tiger Salamander's range in southeast Manitoba, and all known sites are close to roads. Although most roads in the vicinity of the known sites are gravel, and traffic volumes are relatively low, inopportune timing of traffic when salamanders are crossing roads during their seasonal migrations has the potential to seriously harm the population, known from only one recent site.

Natural System Modifications

Hydrology of the farmlands within the Eastern Tiger Salamander's range in Manitoba has been extensively modified and continues to be modified. Extensive ditching is required to remove snowmelt from farmland. Temporary and semi-permanent wetlands may be drained in the process, or their hydroperiod is reduced. While the creation of dugouts for livestock water holes may somewhat compensate for their loss, wetlands that dry up in some years are probably extremely valuable as breeding sites, because they lack predatory fish. Crop irrigation using groundwater occurs for some crops, such as strawberries, but is uncommon in eastern Manitoba (Goerzen pers. comm. 2013). The overall effect of altering natural hydrology is probably negative and may not allow the maintenance of a metapopulation structure of tiger salamander populations across the landscape.

Pollution

Agricultural chemicals, including fertilizers, pesticides and herbicides are known to directly and indirectly affect several amphibian species, including tiger salamanders (Power *et al.* 1989; Bishop 1992; Larson *et al.* 1998; Bishop *et al.* 1999). Griffis-Kyle and Ritchie (2007) found that although Eastern Tiger Salamander larvae in Minnesota did not experience significantly reduced survival when exposed to elevated concentrations of ammonium nitrate, their development was slowed. Indirect effects are likely to be more insidious because they do not necessarily announce their presence with mass mortality events. Rather, they reduce individual fitness by decreasing the sizes at which larvae metamorphose, interfere with immune function and may alter an individual's ability to avoid predation (Bridges 1999; Taylor *et al.* 1999; Diana *et al.* 2000; Griffis-Kyle and Ritchie 2007). Numerous studies have investigated the negative effects of environmental steroids, dioxins and other pesticide residues on larval Western Tiger Salamanders (Norris *et al.* 1997; Clark *et al.* 1998; Vajdaa and Norris 2005) but not on Eastern Tiger Salamanders.

In southeast Manitoba, the known range of the species is to the east of extensive croplands subjected to herbicide and pesticide use, and therefore pollutant runoff from these sources to salamander breeding sites is probably low and confined to localized areas where annual crops are grown. Livestock manure may contribute to high nutrient loads of water bodies over much of the species' range in Manitoba. In addition to nitrates, phosphates, and herbicides from local sources, long-distance transport of persistent organic pollutants is probably prevalent within the species' range. Long-distance transport of agricultural pollutants could occur from croplands to the west, but no data are available. Wind-borne agricultural pesticides have been correlated with declines of frog populations in California (Davidson *et al.* 2002).

Northeastern US populations of Eastern Tiger Salamanders are negatively affected by acid deposition; at low pH, the salamanders exhibited reduced growth and longer larval periods (Kiesecker 1996). Acid rain may not be a problem in Manitoba, however, as the land surface is underlain by basic rocks, which would help neutralize acids.

In Ontario, over 20% of Point Pelee National Park's terrestrial environment was farmed at one time, with DDT and other pesticides, as well as fertilizers applied to agricultural crops (Graham, undated). DDT was also applied to wetlands for mosquito control in the park (Russell *et al.* 1995). These toxins were found in Spring Peepers (*Pseudacris crucifer*) in Point Pelee National Park in 1993 despite discontinuation of DDT use in 1967 (Russell *et al.* 1995).

Invasive and Other Problematic Species

Infectious disease and parasites

A number of disease agents have been implicated in amphibian declines (Carey *et al.* 1999; Daszak *et al.* 1999). Ranaviruses, a group of closely related viruses belonging to the taxonomic group Iridoviridae, have been noted as causative agents of disease in amphibians (Gray *et al.* 2009; Schock *et al.* 2009). The *Ambystoma tigrinum* Virus (ATV), isolated from populations of the Sonoran Tiger Salamander (*A. mavortium stebbinsi*) in Arizona, periodically causes mass mortality in populations of this subspecies (Jancovich *et al.* 1997) and has been implicated in several die-offs of Western Tiger Salamanders in Saskatchewan and Manitoba, as well as several other western US states (Jancovich *et al.* 1997; Bollinger *et al.* 1999; USGS 2000; Schock 2001). Although there are no documented cases of declines linked to ranaviral infection in Eastern Tiger Salamanders, ATV is a potential threat that could decimate local populations.

The chytrid fungus, *Batrachochytrium dendrobatidis*, which causes the amphibian disease chytridiomycosis, is considered to be a major factor in amphibian population declines worldwide (Berger *et al.* 1998; Carey *et al.* 1999; Daszak *et al.* 1999; Lips *et al.* 2008), but Daszak *et al.* (2005) concluded that it was not the agent most responsible for declines in Eastern Tiger Salamander populations in South Carolina. At present, there are no documented cases of chytrid fungus from amphibians in Manitoba (Watkins pers. comm. 2013), but it is a potential future threat.

Eastern Tiger Salamanders are also subject to parasitic infections. Perpinan *et al.* (2010) note mortality, morbidity and physical deformities in Eastern Tiger Salamanders associated with encysted infection by trematodes, genus *Clinostomum*.

Introduced fishes

Various species of fishes are known to be predators of tiger salamander eggs and larvae, and the presence of introduced fish in previously fishless Eastern Tiger Salamander breeding ponds will reduce or eliminate tiger salamander populations (Collins and Wilbur 1979). Predatory fish extirpate ambystomatid salamanders by preying on larvae, inhibiting larval growth, and altering salamander behaviour in non-adaptive ways (Burger 1950; Sprules 1972; Taylor 1983; Semlitsch 1987; Semlitsch 1988; Sih *et al.* 1988, 1992; Petranka 1998; Tyler *et al.* 1998). Large, deep water bodies that foster neotenic tiger salamander populations are often attractive sites for introducing game fish, leading to the rapid extirpation of the salamanders. In Manitoba, stocking with trout occurs in some ponds on public lands and is controlled by Manitoba Fisheries. Commercial aquaculture has been practised in Manitoba since the 1960s. Annually, there were 25-30 licensed commercial operators, mostly on private lands, and 500 – 600 unlicensed hobby farmers who buy fish for stocking of private ponds (Manitoba Water Stewardship Fisheries Branch 2004). Current extent of fish stocking on private lands is unknown. Stocking probably occurs also for mosquito control.

Climate Change

Increased summer temperatures, decreased summer rainfall and increased frequency and severity of droughts are predicted on the Canadian prairies as a consequence of climate change (Sauchyn *et al*. 2005; Barrow 2010; Kulshreshtha 2011). Although drought is a natural phenomenon and tiger salamanders are adapted to life in arid landscapes, sustained periods of drought have been strongly implicated in the decline of Eastern Tiger Salamanders in South Carolina (Daszak *et al*. 2005) and pose a similar threat to the species in southeastern Manitoba. Two consecutive years of drought are unusual for this area of Manitoba but was observed in 2011 – 2012; as a result, the only known ponds with recent observations of the species were dry (Watkins pers. comm. 2013). If such droughts extended over 4 – 5 consecutive years during the breeding period in spring, consequences for the salamander population would be dire. The transitional zone where the salamanders occur is characterized by wetter climate than the more arid areas to the west, and prolonged, multi-year droughts may not be likely in the next 10 years. However, the situation is likely to worsen over the long term as climate change proceeds, and larger areas may be affected by more frequent extreme events, floods or droughts.

Limiting Factors

Eastern Tiger Salamanders are principally habitat limited. They require semi-permanent, fishless breeding ponds to which they appear to be highly philopatric (Madison and Farrand 1998). Terrestrial adults require adjacent terrestrial habitat characterized by friable or sandy soils into which they can dig. Loss or severe degradation of either of these required habitats, or the corridors between them, is detrimental to Eastern Tiger Salamander populations.

Number of Locations

In total, there are five locations, as defined by IUCN, for Eastern Tiger Salamanders in Manitoba (Figure 3; 1969 record from Steinbach is considered historical, and the population is probably no longer extant). Each of these locations is vulnerable to a single threatening event, such as an extensive drought, introduction of predaceous fishes, chemical spill or epidemic disease, which may rapidly affect all individuals present. As the several records southwest of Gardenton are all closely contiguous and therefore likely occupied by a single metapopulation, they can be collectively considered one location.

PROTECTION, STATUS, AND RANKS

Legal Protection and Status

The Eastern Tiger Salamander in Ontario is listed under the *Species at Risk Act* as Extirpated, with Parks Canada Agency as the responsible jurisdiction. A draft recovery strategy (Ngo *et al*. 2009) recommends no action be taken. *Ambystoma tigrinum* is listed as Extirpated under Schedule 2 of Ontario's *Endangered Species Act*, 2007.

As the previous 2001 COSEWIC assessment of tiger salamanders in Canada was done before the taxonomic division of Eastern Tiger Salamanders from Western Tiger Salamanders was generally accepted, the Eastern Tiger Salamanders in Manitoba were not distinguished from other tiger salamanders found on the Canadian prairies. They were previously assessed by COSEWIC as Not at Risk as part of the Prairie populations of tiger salamanders that included subspecies of the Western Tiger Salamander (the Prairie / Boreal population of the Western Tiger Salamander has since been assessed by COSEWIC as Special Concern).

Non-Legal Status and Ranks

Non-legal status rankings for Eastern Tiger Salamanders are confused because of the changes in its taxonomy. In some instances it is treated as a distinct species, in others as a subspecies, and in others it is not considered separately from Western (= Barred) Tiger Salamanders at all.

As a distinct entity, the Eastern Tiger Salamander is listed by NatureServe (2011) as G5T5 (globally secure subspecies of a globally secure species) and N5 (nationally secure) in the United States. At the subnational level in US states close to Canada, Eastern Tiger Salamanders are listed as SNR (not ranked) in Wisconsin and Minnesota. They are listed as S2 (imperiled) in Manitoba, SX (presumed extirpated) in Ontario and NNR (nationally unranked) in Canada as a whole.

Not distinguishing between *A. tigrinum* and *A. mavortium,* NatureServe (2011) collectively lists "tiger salamanders" as G5 (globally secure) and N5 (nationally secure) in the US and Canada. At the subnational level in US states close to Canada, they are listed as SX in Pennsylvania, S1S2 (critically imperiled to imperiled) in New York, S3 (vulnerable) in Ohio, S3S4 (vulnerable to apparently secure) in Michigan, S4 (apparently secure) in Wisconsin and as SNR (unranked) in Minnesota. They are listed as S4S5 (apparently secure to secure) in Manitoba and SX in Ontario. Their status is LC (Least Concern) on the IUCN Red List.

Habitat Protection and Ownership

In Manitoba, there are no areas specially set aside for Eastern Tiger Salamanders. However, there are anecdotal accounts of Eastern Tiger Salamanders being found in ponds on the Tall Grass Prairie Preserve near Tolstoi (Watkins pers. comm. 2011). Over 20 km^2 are protected in the preserve and several organizations assist in land preservation in the Manitoba tall grass prairie, including the Nature Conservancy of Canada, Nature Manitoba, Environment Canada, Manitoba Conservation and the Manitoba Habitat Heritage Corporation.

Previously, Manitoba resident holders of a Reptile and Amphibian Pickers Licence could collect, hunt and sell tiger salamanders, of either species, from 1 August to 30 September. In 1988, a permit for 41 kg of live tiger salamanders was granted (Koonz 1992), though Koonz (1992) also suggested that many sales likely went unrecorded. Under current regulations (M.R. 56/2007), however, collecting and selling tiger salamanders is not permitted in Manitoba. On the other hand, Section 15(2) of the Manitoba *Wildlife Act* does allow a person to take tiger salamanders for personal use, presumably as bait for fishing. The Manitoba *Wildlife Act* does not differentiate between Western Tiger Salamanders and Eastern Tiger Salamanders.

Within National Parks in Canada, including Point Pelee, Eastern Tiger Salamanders are protected under the *Canada National Parks Act* and wildlife regulations. A research permit is required in order to collect, capture or release salamanders for any purpose in any national park.

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BIOGRAPHICAL SUMMARY OF REPORT WRITER

Prof. David M. Green obtained his B.Sc. in Zoology from the University of British Columbia and his M.Sc. and Ph.D., both also in Zoology, from the University of Guelph. He came to the Redpath Museum of McGill University in 1986 and is now a Full Professor and the Director of the Museum.

Prof. Green was Chair of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and served as co-chair of COSEWIC's Amphibians and Reptile Subcommittee for 14 years. He was a member of the Science Advisory Council of Fisheries and Oceans Canada and currently is on the Council of Canadian Academies' Panel on the State and Trends of Biodiversity Science in Canada. He is an Associate Editor for the journal Diversity and Distributions and the Zoological Journal of the Linnean Society, and is a Fellow of the Linnean Society of London.

Prof. Green's research concerns the ecology, genetics, and evolution of amphibians. He has particular interests in species at risk, including the determinants of species' ranges and population declines, population dynamics, dispersal and recruitment in amphibians, and declining amphibian populations. He has authored over 120 refereed publications and book chapters, and more than 100 miscellaneous other publications and reports. True to his calling, few of his publications fail to mention amphibians in some manner.

COLLECTIONS EXAMINED

Specimens from the Manitoba Museum

Specimen No.	Locality	Date	Collector(s)
Ambystoma mavortium diaboli (Gray Tiger Salamander)			
MM 365	Baldur, 8 km N, Manitoba	25 May 1989	J. Dubois, W.B. McKillip, W.B. Preston
MM 367	Delta Beach, Lake Manitoba	29 Aug. 1972	G. Stelman
MM 368	Erickson, 6.9 km S, Hwy #10, Manitoba	2 Sept. 1970	W.B. Preston
MM 369	St. François Xavier, Manitoba	1 Mar. 1983	P. Dunlop
MM 373	Virden, 2 km E, Manitoba	10 Aug. 1980	J. Dubois
MM 377	Killarney, 7.5 km N, 10 km E., Manitoba	11 Sept. 1978	H.W.R. Copland
MM 379	Portage La Prairie, 72.4 km W of Winnipeg	16 Sept. 1971	G. Lammers

Specimen No.	Locality	Date	Collector(s)
MM 380	Emerson, 1.6 km N, 6.4 km E, Manitoba	19 Oct. 1972	J. Dubois, R.E. Wrigley
MM 384	Carman, Manitoba	no date	W.H. Clark
Ambystoma tigrinum (Eastern Tiger Salamander) – catalogued erroneously as *"Ambystoma mavortium diaboli"* (Gray Tiger Salamander) by W. B. Preston.			
MM 375	SW of Gardenton, Manitoba	26 June 1987	J. Dubois, M. Oberpichler

Appendix 1. Known localities for Eastern Tiger Salamanders, *Ambystoma tigrinum*, in Canada. Coordinates are rounded for confidentiality of records.

Specimen No. or reference*	Locality†**	Latitude (N)	Longitude (W)	Date	Collector(s)
Manitoba:					
Zoology Museum, Univ. of Manitoba	Steinbach (Hanover RM) †	**BLOCKED TEXT**	**BLOCKED TEXT**	May 1969	K. Stewart
MM 375	SW of Gardenton (Stuartburn RM), Manitoba	**BLOCKED TEXT**	**BLOCKED TEXT**	26 June 1987	J. Dubois, M. Oberpichler
ROM 16010-16015 ROM 16020, 16022, 16027, 16029, 16031-41, 17041-44	N of Roseau River (Franklin RM)	**BLOCKED TEXT**	**BLOCKED TEXT**	1987	L. Lowcock
ROM 16009, 16016, 16019, 16026, 17033-40	Tolstoi (Stuartburn RM)	**BLOCKED TEXT**	**BLOCKED TEXT**	1987	L. Lowcock
Field Notes: Manitoba Mus. Man & Nature Archives 1990	Marchand (La Broquerie RM)	**BLOCKED TEXT**	**BLOCKED TEXT**	1990	W.B. Preston
Manitoba Herps Atlas	SW of Gardenton (Stuartburn RM)			11 Apr., 28 July 2011, March 2012	D.C. Collicut, W. Watkins
Ontario:					
Specimen No. or reference	Locality	Latitude	Longitude	Date	Collector(s)
CMNAR 623	Point Pelee (Essex Co.)	-	-	2 October, 1915	P.A. Taverner

* Museum Abbreviations: MM = Manitoba Museum, ROM = Royal Ontario Museum, CMNAR = Canadian Museum of Nature Amphibians and Reptiles Collections.

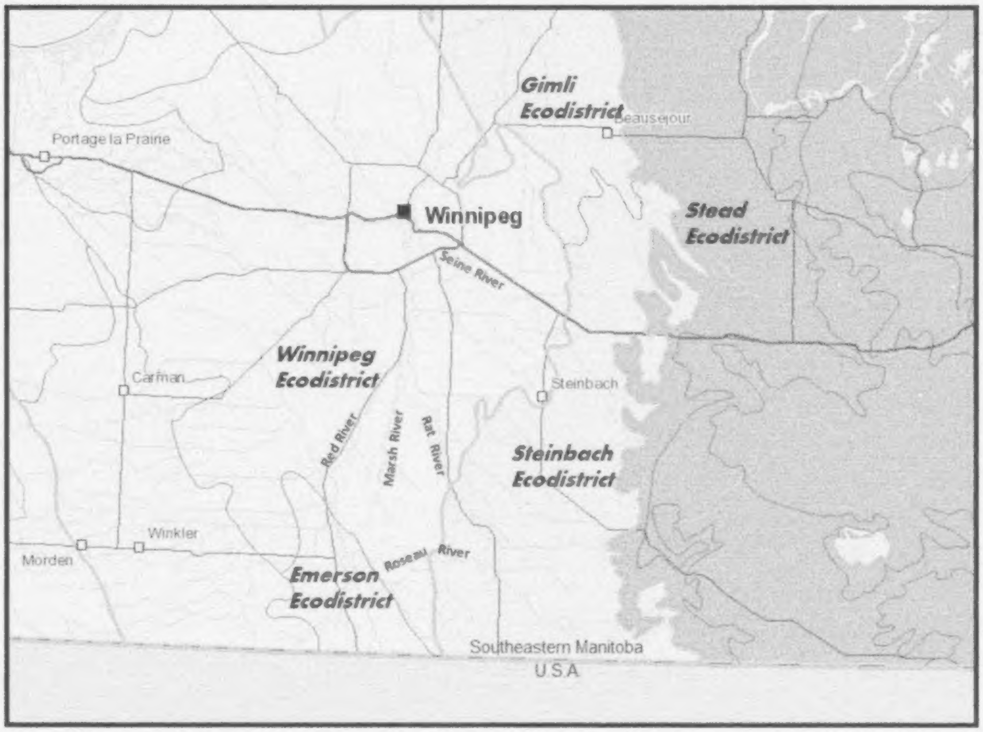
**RM = Regional Municipality

†Likely extirpated based on habitat trends and age of record

Appendix 2. Map of southeastern Manitoba showing Terrestrial Ecozones.

(yellow = Prairie Ecozone; light green = Boreal Plains Ecozone; dark green = Boreal Shield Ecozone). Ecoregions represented within the respective ecozones are: Lake Manitoba Plain Ecoregion (yellow), Interlake Plain Ecoregion (light green), and Lake of the Woods Ecoregion (dark green). Ecodistrict boundaries appear as thin black lines, and five have been labelled following Smith *et al.* (1998).

All known occurrences of Eastern Tiger Salamander are within the Steinbach Ecodistrict. Map was created and annotated from the web map available from the National Ecological Framework for Canada, Agriculture and Agri-Food Canada. (http://ecozones.ca/english/).



Appendix 3. Threats calculator for the Eastern Tiger Salamander, Prairie Population. Threat categories that were considered not applicable were left blank.

THREATS ASSESSMENT WORKSHEET

Species or Ecosystem Scientific Name	*Ambystoma tigrinum* - Prairie Population (Manitoba)
Date (Ctrl + ";" for today's date):	29/08/2013
Assessor(s):	J. Bogart, D. Fraser, D. Green, K. Ovaska, C. Paszkowski, W. Watkins
References:	2013 COSEWIC status report (draft); Rat-Marsh River Watershed Land Use Plan (AESB & MAFRI 2011)

Overall Threat Impact Calculation Help:

		Level 1 Threat Impact Counts	
Threat Impact		**high range**	**low range**
A	Very High	0	0
B	High	2	0
C	Medium	4	1
D	Low	0	5
	Calculated Overall Threat Impact:	Very High	High

Overall Threat Comments: Generation time ca. 5 years, 3 generations = 15 years; assessment was done for the entire range, not just for the 6 sites known at this time.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development		Negligible	Negligible (<1%)	Serious (31-70%)	High (Continuing)	
1.1	Housing & urban areas		Negligible	Negligible (<1%)	Serious (31-70%)	High (Continuing)	Steinbach is the only community that is growing (only 1 old record from that area); all other small communities in the area are in decline.
1.2	Commercial & industrial areas						None known; sand & gravel quarrying is captured elsewhere.
1.3	Tourism & recreation areas						Only known example: St. Malo provincial park is expanding recreational activities to attract more people (captured elsewhere)
2	Agriculture & aquaculture	CD	Medium - Low	Large (31-70%)	Moderate-Slight (1-30%)	High (Continuing)	
2.1	Annual & perennial non-timber crops	D	Low	Small (1-10%)	Serious - Moderate (11-70%)	High (Continuing)	There are relatively little annual croplands in the prairie - forest transition zone occupied by the species; most of the croplands are to the west of where the salamanders occur.
2.2	Wood & pulp plantations						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
2.3	Livestock farming & ranching	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	High (Continuing)	Livestock pasture dominates the landscape within the species' range; 32% are in grasslands & pasture in the Lower Rat-Marsh River drainage (AESB & MAFRI 2011). The area is also known for hog farming. Effects of cattle ranching are uncertain: on one hand, grazing prevents bush encroachment into grasslands and ponds may be created or deepened for cattle watering holes; on the other hand, natural wetlands & their margins can be trampled and destroyed by cattle. The net effect is probably negative as natural wetlands are placed at risk but depends on the intensity of stocking.
2.4	Marine & freshwater aquaculture		Unknown	Unknown			Many ponds in the area are snowmelt ponds, and most dry periodically (every few years), and would require continuous fish stocking. The group conducting this assessment was not aware of fish stocking of ponds, but it may occur occasionally by individual farmers, e.g., for mosquito control (dealt with under Introduced Species category).
3	Energy production & mining		Negligible	Negligible (<1%)		Unknown	
3.1	Oil & gas drilling						None within the species' range.
3.2	Mining & quarrying		Negligible	Negligible (<1%)	Unknown	Unknown	Sand & gravel quarrying is widespread but mostly at outer edges of core range of the Eastern Tiger Salamander. Most existing mining areas have already been exploited but are expanding. Quarrying results in the destruction of existing ponds and their potential replacement by drainage ditches/ponds. However, it also has potential to create pond habitat, as noted in Alberta.
3.3	Renewable energy						No wind farms are within the species' range or are proposed.
4	Transportation & service corridors	CD	Medium - Low	Pervasive (71-100%)	Moderate-Slight (1-30%)	High (Continuing)	
4.1	Roads & railroads	CD	Medium	Pervasive (71-100%)	Moderate – Slight (1-30%)	High (Continuing)	All known sites are close to roads (within about a mile), and tiger salamanders are vulnerable to roadkill during their seasonal migrations. There are examples of Western Tiger Salamander getting killed on roads in Manitoba (St. Leons area). There is anecdotal information of large numbers of salamanders on road near Gardenton from several years ago.
4.2	Utility & service lines						
4.3	Shipping lanes						
4.4	Flight paths						
5	Biological resource use		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
5.1	Hunting & collecting terrestrial animals		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Collection of salamanders for pets or bait might be happening at a low level. Collection for bait is allowed in MB for personal use, but if it occurs, the scale is small.
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting						
5.4	Fishing & harvesting aquatic resources						
6	Human intrusions & disturbance		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	
6.1	Recreational activities		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Expansion of recreational activities is in progress in St. Malo Provincial Park (reservoir; dam on river has created a small lake). The park is at the edge of the species' range.
6.2	War, civil unrest & military exercises						
6.3	Work & other activities						
7	Natural system modifications	BD	High - Low	Large (31-70%)	Serious - Slight (1-70%)	High (Continuing)	
7.1	Fire & fire suppression		Unknown	Unknown			Wildfires are frequent enough to prevent forest & shrub encroachment on grasslands. Two large wildfires were in the Tolstoi area in recent years. Forestry fire dugouts in the east for fire suppression purposes, outside the known range of the species.
7.2	Dams & water management/use	BD	High - Low	Large (31-70%)	Serious - Slight (1-70%)	High (Continuing)	Ditching designed to take snowmelt off land as fast as possible occurs throughout the species' range (water may be channelled into larger rivers, which are not habitat for salamanders). The commercial crops irrigated are mainly strawberries, most farms use groundwater and one farm uses river water (which they have a licence for) (Goerzen pers. comm. 2013). Many ponds dry up seasonally in dry years - only dugouts survive. Although tiger salamanders are adapted to withstand dry conditions and can skip breeding in dry years, a series of dry years will be problematic & may result in population declines. Creation of dugouts or deepening of temporary ponds may be beneficial for salamanders, but not if stocked with fish or excessively trampled by cattle. These sites may be the only sites available in dry years. Although some impacts may be positive, the overall effect of changing natural hydrology is probably negative.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7.3	Other ecosystem modifications						
8	Invasive & other problematic species & genes	BD	High - Low	Pervasive (71-100%)	Serious - Slight (1-70%)	High (Continuing)	
8.1	Invasive non-native/alien species	BD	High - Low	Pervasive (71-100%)	Serious - Slight (1-70%)	High (Continuing)	Chytrid has not been identified from amphibians in the province yet but is only a matter of time. Ranavirus prevalence has not been studied east of Red River (ATV - *Ambystoma tigrinum* virus) is native and discussed under next category). Tiger Salamanders do poorly with predatory fish. Fish stocking of ponds in public waters is controlled by Manitoba Fisheries. Commercial aquaculture has been in operation in Manitoba since 1960s, but mostly in the west. Annually, there are 25-30 licensed commercial operators, mostly on private lands, and 500-600 unlicensed hobby farmers who buy fish for stocking private ponds (Manitoba Water Stewardship Fisheries Branch 2004). Current extent of fish stocking on private lands is unknown. It may also occur for mosquito control. Timing is High, based mostly on introduced fish.
8.2	Problematic native species	BD	High - Low	Pervasive (71-100%)	Serious - Slight (1-70%)	Moderate (Possibly in the short term, < 10 yrs)	*Ambystoma tigrinum* virus (ATV) is prevalent throughout Western Tiger Salamanders range but has not been searched for in SE Manitoba within the Eastern Tiger Salamander's range; it doesn't always result in disease. Epidemics have been documented for the Western Tiger Salamander in Alberta and Saskatchewan. Habitat connectivity is an issue and affects spread of disease. Invasive non-native strains of ATV may be present due to moving around larvae and fish. Impacts tied to other land uses.
8.3	Introduced genetic material						Not a threat at present. Provincial laws allow taking of larvae for personal use (bait, educational), but the numbers appear to be very small, no use for bait is known, and transport among drainages is prohibited. Some tiger salamanders are sold illegally in pet stores, but no salamanders have been found or seized in checks in Manitoba.
9	Pollution	C	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	
9.1	Household sewage & urban waste water						
9.2	Industrial & military effluents						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
9.3	Agricultural & forestry effluents	C	Medium - Low	Pervasive (71-100%)	Moderate to Slight (1-30%)	High (Continuing)	Livestock manure contributes to high nutrient loads of water bodies, and much of the species' range is used for cattle and other livestock raising and pastures. Hog industry is prevalent in the area, but a moratorium is in place on expansion of hog operations. Herbicide Atrazine, which is an endocrine disruptor in frogs (up to 80% of populations can be affected) is used very little in Manitoba (detected in <2% of water samples since 1997). Because the known range is to the east of croplands, herbicides and pesticides probably contribute little to this rating.
9.4	Garbage & solid waste						
9.5	Air-borne pollutants		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Range is far from oil and gas developments. Acid rain may not be a problem, as the land surface is underlain by basic rocks, which would neutralize acids. Persistent organic pollutants in rain are probably prevalent everywhere. Long-distance transport of agricultural pollutants could occur from croplands to the west. Wind-borne agricultural pesticides have been correlated with declines of frog populations in California (Davidson *et al.* 2002).
9.6	Excess energy						
10	Geological events						
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides						
11	Climate change & severe weather	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	
11.1	Habitat shifting & alteration		Unknown	Unknown			

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.2	Droughts	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	Predicted impacts from climate change are mostly from prolonged droughts, which are already occurring, but increasing frequency of flooding and other extreme weather events that modify the hydrology are also of concern. Impacts on salamanders are context-dependent: some populations may be wiped out, whereas those in other areas would be less affected. Although tiger salamanders can skip breeding in dry years, several (5- 6 years) in a row could be devastating. Two consecutive years of drought are unusual for this area, but yet this was observed in 2011 - 2012. Ponds need to have water in spring for breeding to occur (tiger salamanders will skip breeding, even if ponds fill up later in summer). Pervasive droughts over large areas for series of years would have high impacts. The situation is likely to become worse over the long term (>10 years) as climate change proceeds and larger areas may be affected by more frequent droughts.
11.3	Temperature extremes		Unknown	Unknown			Colder winters could be a problem, if variability in winter temperatures increases. Increased water temperatures are probably not a threat because the salamanders are relatively tolerant and occur far south in US; adult animals can retreat underground.
11.4	Storms & flooding		Unknown	Unknown			In general, more severe and frequent storms are predicted. Flooding caused by storms could increase pollutant and fish transport into breeding ponds.